

EUROTrough Progress and “NEXTrough” Opportunities for an Euro-American Trough Alliance

Trough Meeting

SUNLAB

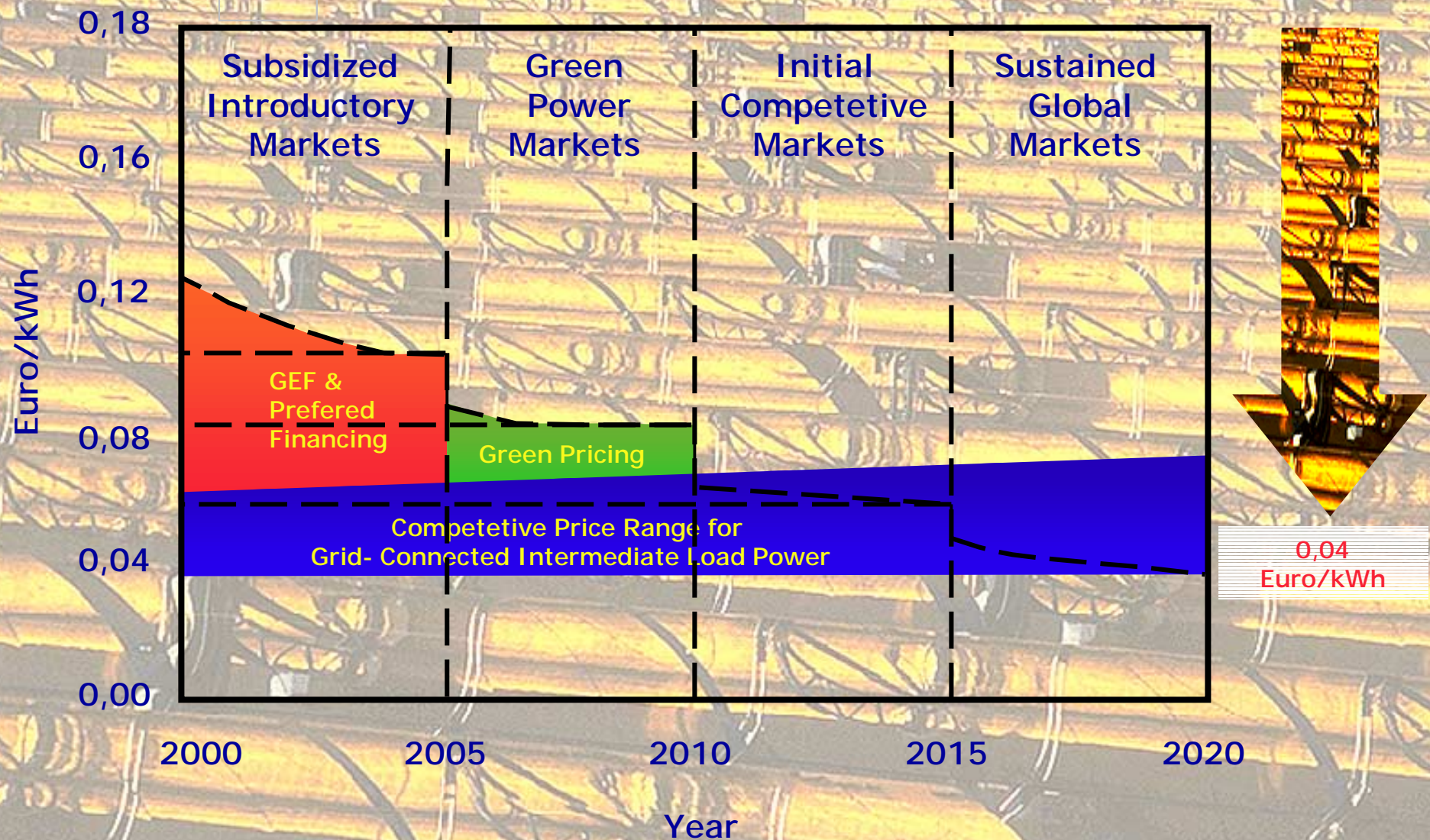
Madison, June 18, 2000

Michael Geyer

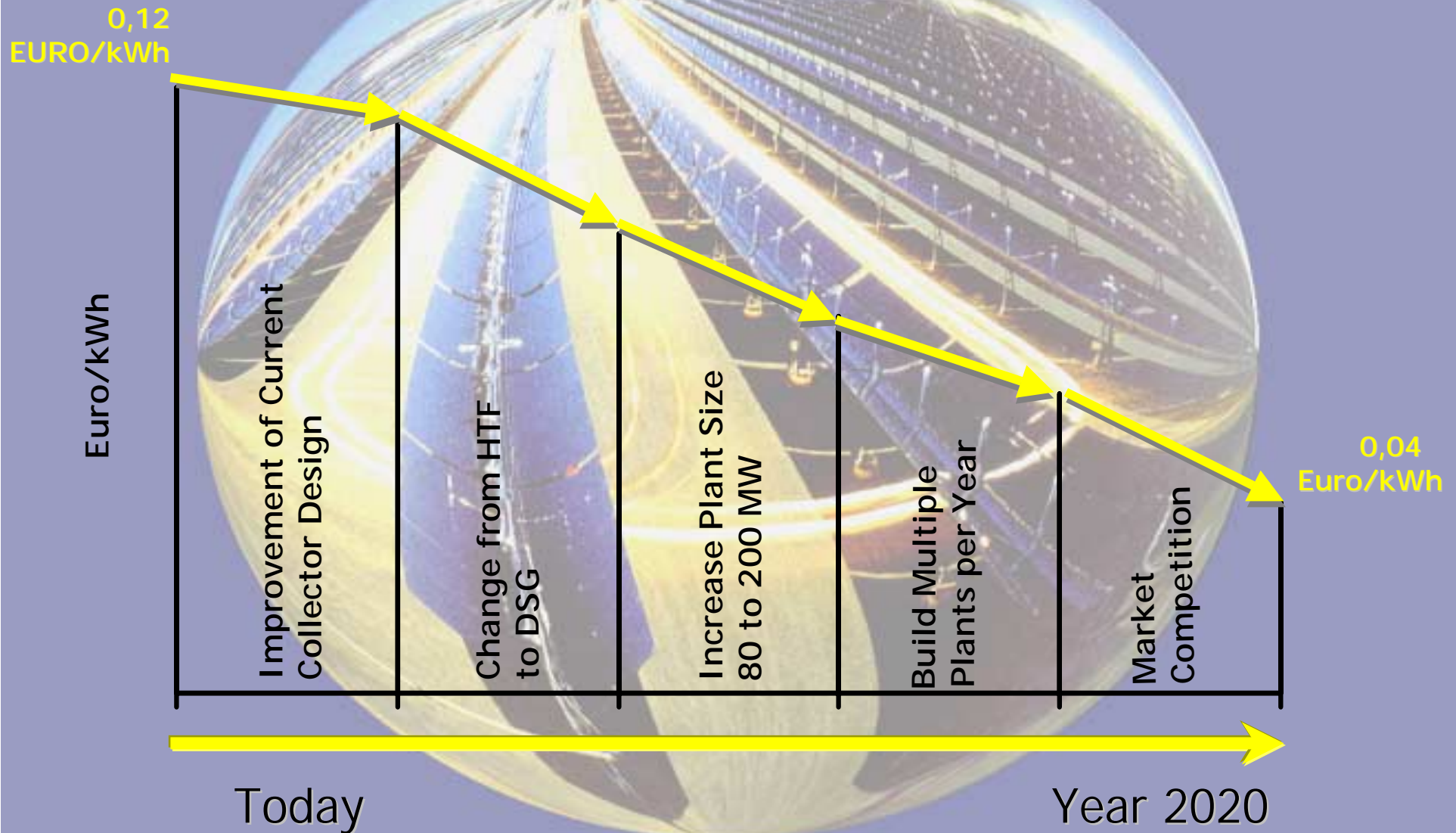
DLR Deutsches Zentrum für Luft- und Raumfahrt

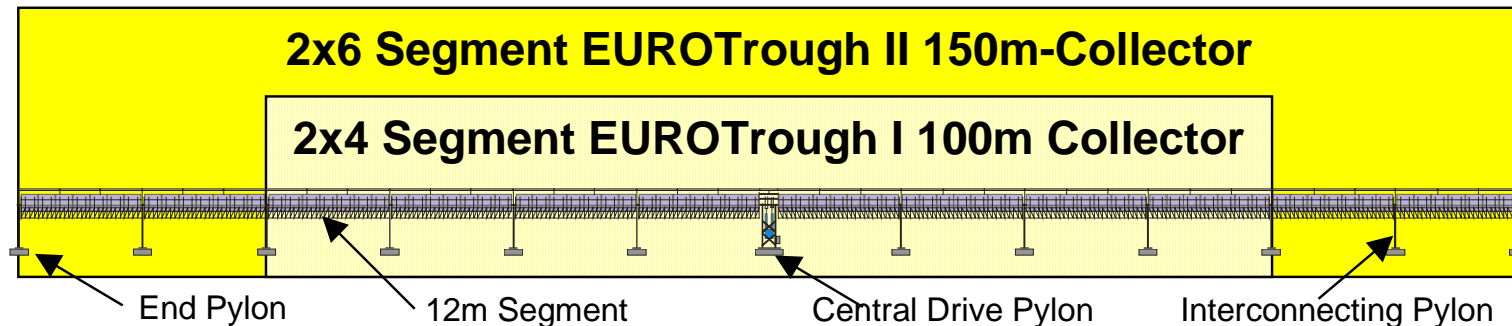
Plataforma Solar de Almeria

Parabolic Trough Market Cost Reduction Perspectives



Cost Reduction Potentials of Parabolic Trough Technology





EUROTrough Phase I

1.8.1998 - 31.1.2001

Cost: 3 Mio Euro

(40%Partners, 40%EU, 20%BMW i)

- Develop 100m/8segment
EUROTrough Collector Design
Deliverable: Manufacturing Dwgs
- Build one half EUROTRough
at Plataforma Solar
Deliverable: 50m Prototype
- Test in PSA's HTF Loop
Deliverable: Qualification Tests

Partners: *Inabensa, Pilkington, SBP, Fichtner, Ciemat, CRES, DLR*

EUROTrough Phase II

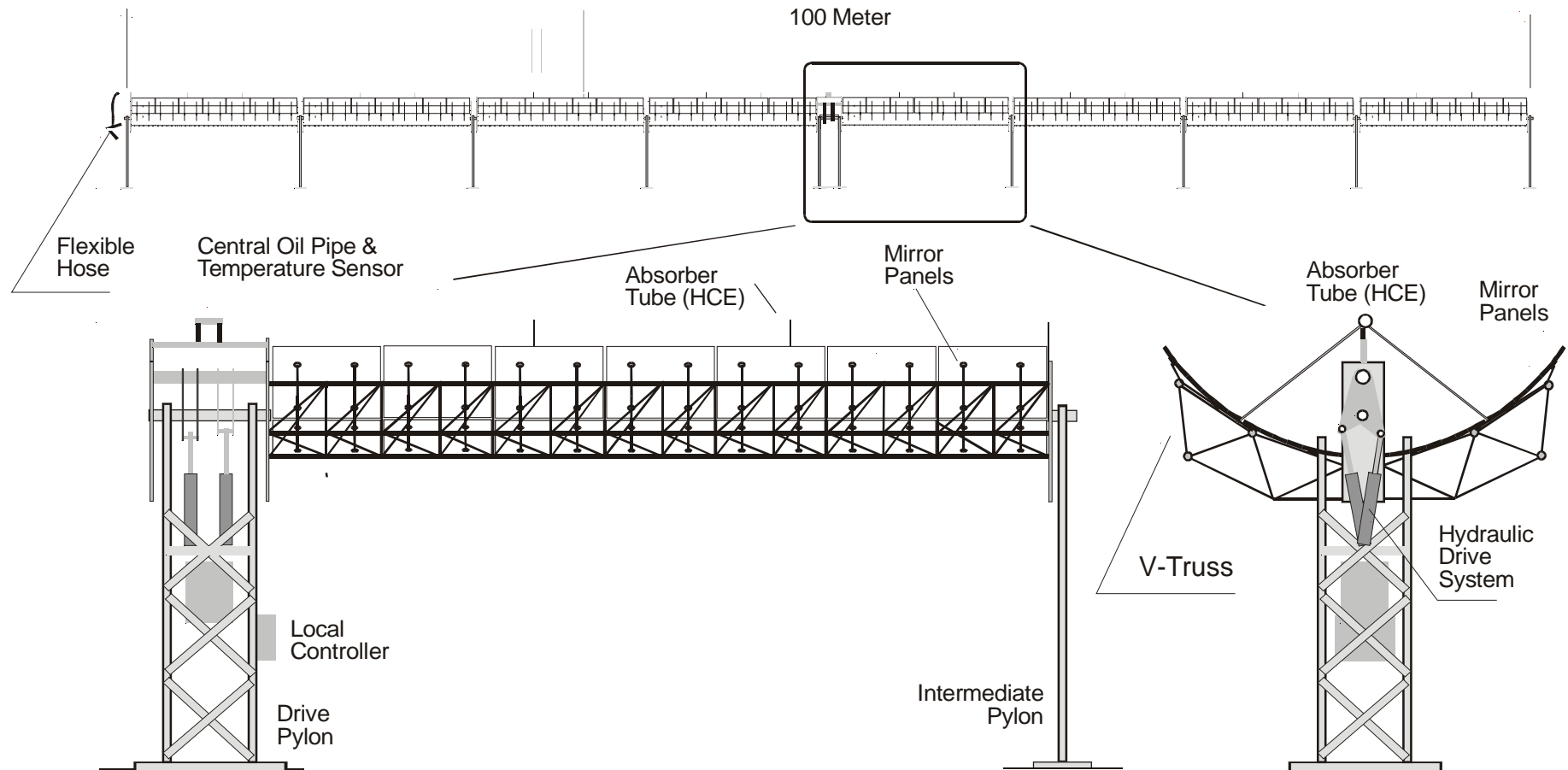
1.10.2000 - 31.12.2002

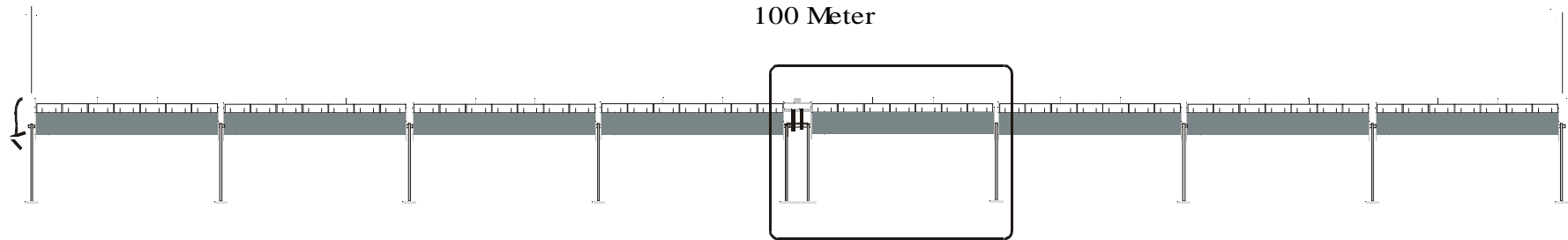
Cost: 2 Mio Euro

(50%Partners, 50%EU)

- Develop 150m/12segment
EUROTrough Collector Design
Deliverable: Manufacturing Dwgs
- Add 2 segments to EUROTRough
prototype at Plataforma Solar
Deliverable: 50+25m Prototype
- Test in PSA's HTF Loop
Deliverable: Qualification Tests

Partners: *Inabensa, Iberdrola, Pilkington, SBP, Solel, Ciemat, DLR*





LS-3 Collector

V-Truss Weight

Drive Pylon

Typical Pylon

Degree of Material Use
(Survival/Stow)

Maximum Wind Bending

Maximum Wind Torsion Surface

Maximum Wind Torsion Axis

Strong

1350 kg

315 kg

135 kg

93%

6.9mm

5.4mrad

5.3mrad

Regular

1068 kg

265 kg

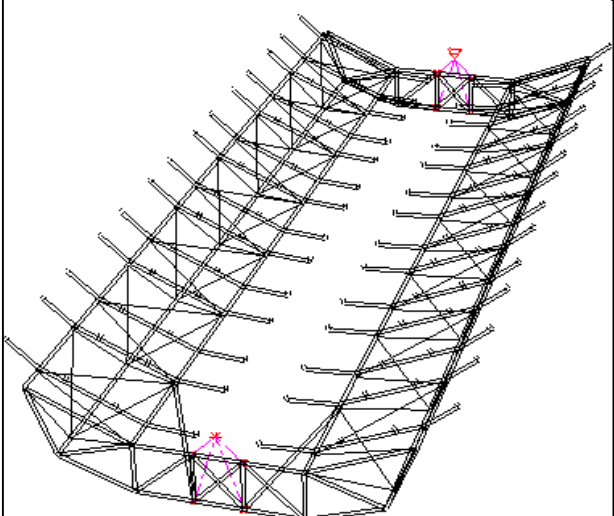
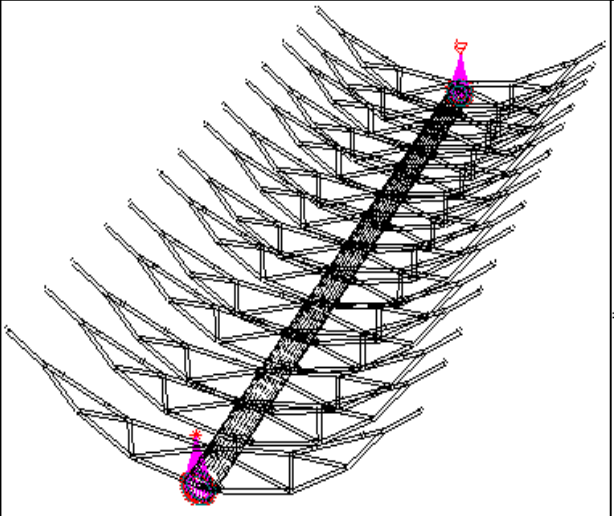
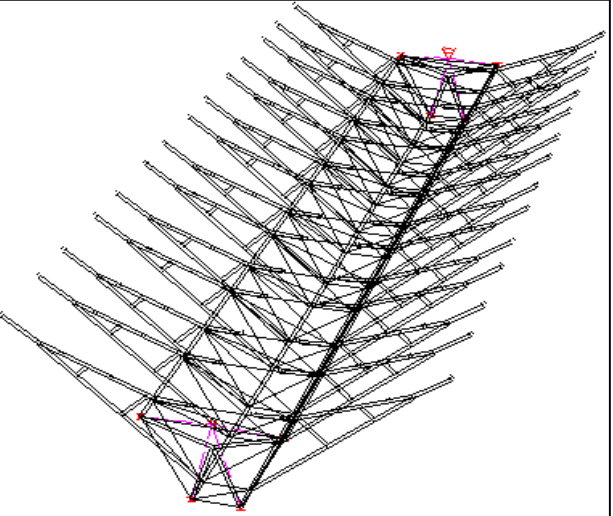
92 kg

99%

10.2mm

5.5mrad

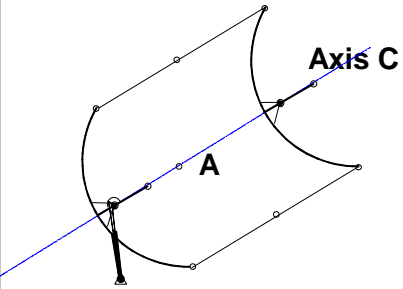
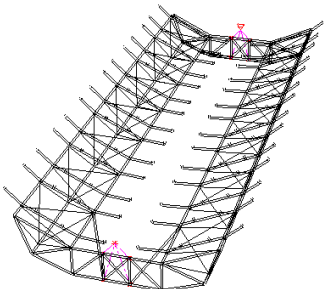
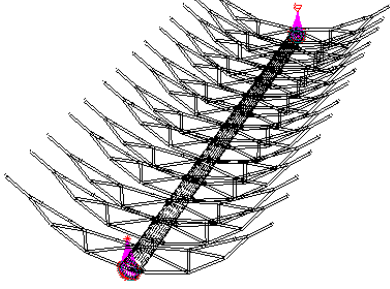
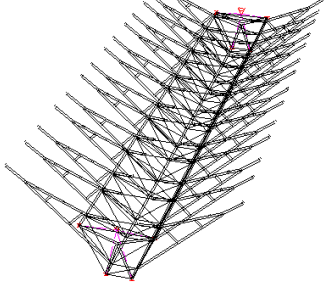
7.7mrad

LS-3 Space Frame	LS-2 Torque Tube	ET Torque Box
 <p>A 3D wireframe diagram of a space frame structure. It features a central longitudinal beam with multiple cross-bracing members. The structure is shown in a perspective view, highlighting its complex, interconnected geometry. Pink and red markers are visible at specific joints and along the beam.</p>	 <p>A 3D wireframe diagram of a torque tube structure. It shows a central longitudinal beam with a series of cross-bracing members that form a series of 'X' shapes. The structure is depicted in a perspective view, emphasizing its elongated and symmetrical design. Pink and red markers are present at the ends and along the beam.</p>	 <p>A 3D wireframe diagram of a torque box structure. It features a central longitudinal beam with cross-bracing members that form a series of 'X' shapes. The structure is shown in a perspective view, highlighting its elongated and symmetrical design. Pink and red markers are visible at the ends and along the beam.</p>

- Elaboration of conceptual design criteria
- Elaboration of design options
- Layout of three different structures
- FEM - analysis of the various structures
- Comparison of design options concerning
 - overall collector mass,
 - deformation in operation,
 - stress under survival loads
- Comparison of design options with LS-3 collector
- Consideration of manufacturing, assembly, transportation and erection cost

➔ **Decision on design options**

Summary of the FEM Optimizations

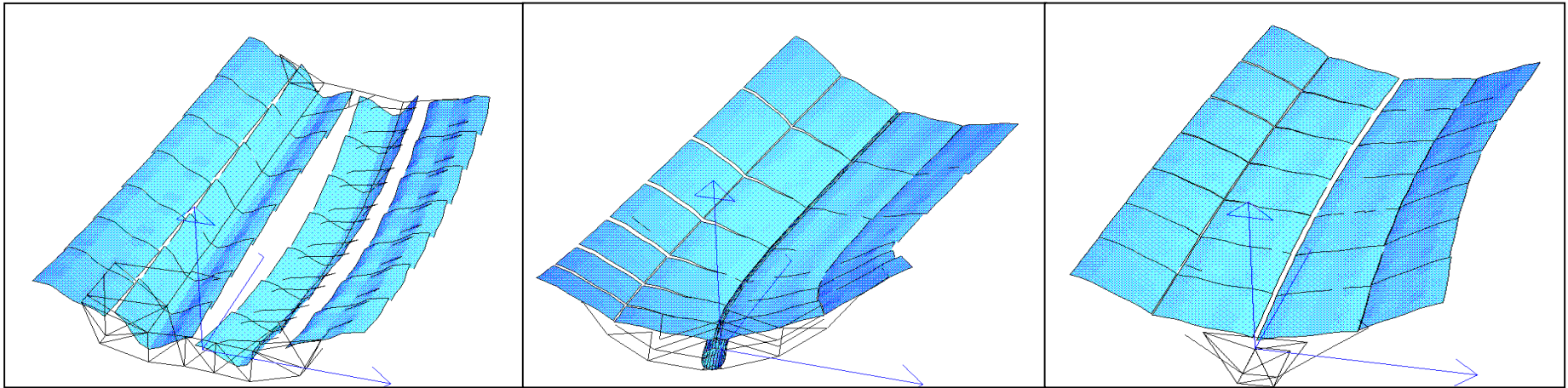
			
	LSS-3 Space Frame Design	LS-2 Torque Tube Design	ET Torque Box Design
Weight	1045 kg	895 kg	915 kg
Use of Sections (Survival /Stow)	32%	55,5	48%
Maximum Wind Bending Distortion Point A	10,5 mm	35,0 mm	7,08 mm
Maximum Wind Bending Distortion surface	4,15 mrad	1,6 mrad	1,6 mrad
Maximum Wind Torsion Distortion surface	4,2 mrad	1,9 mrad	1,7 mrad
Maximum Wind Torsion Distortion Axis C	4,4 mrad	2,0 mrad	1,69 mrad

LS-3 Space Frame

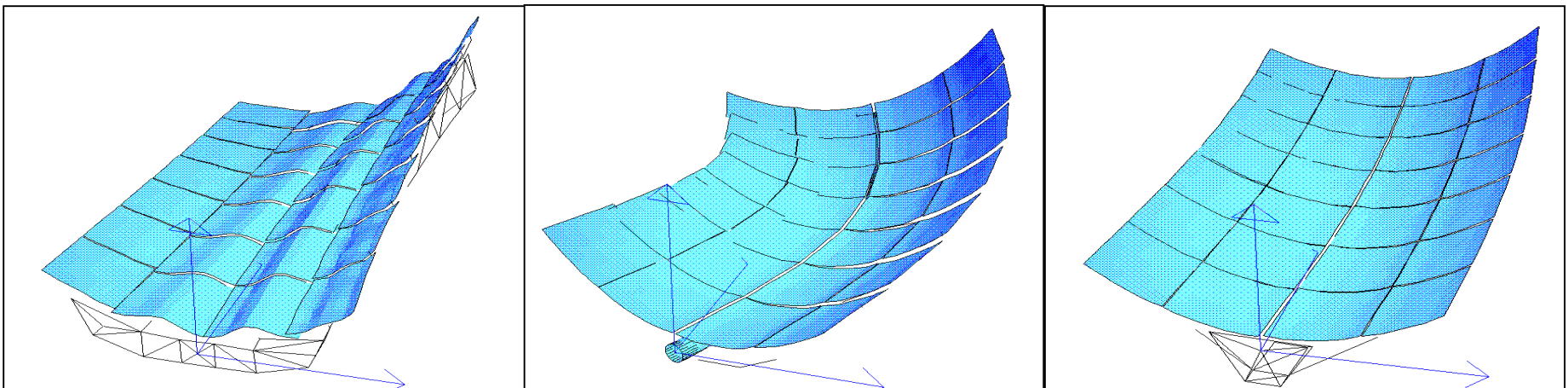
LS-2 Torque Tube

ET Torque Box

Maximum Wind Bending

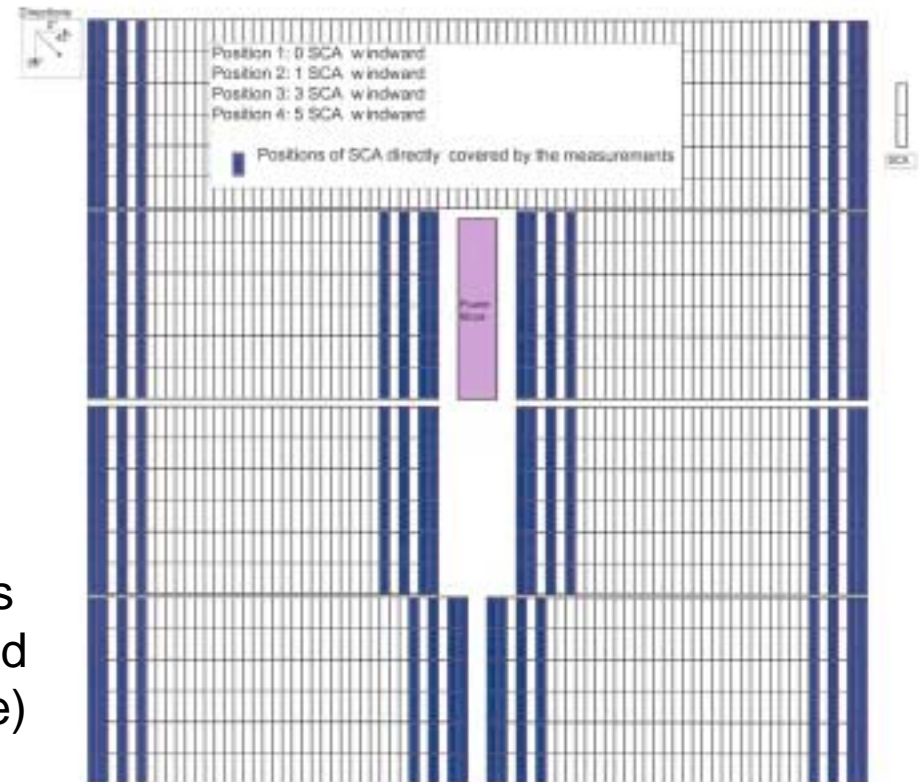


Maximum Wind Torsion





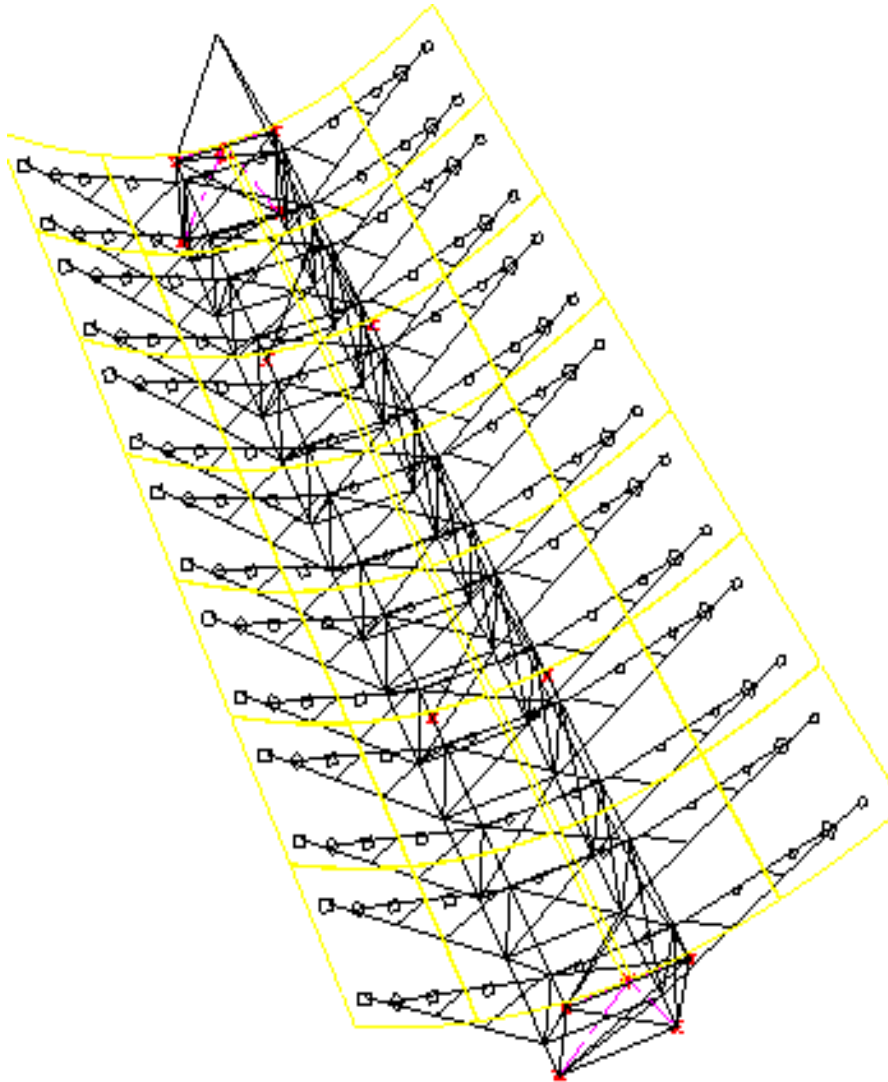
3 different wind directions
5 different positions in the field
(front, 3 in front, 5 in front and single)



Tests performed by:
Wind Tunnel Facility:
Model scale:
Test conditions:
Cost:

Wacker Ingenieure, Birkenfeld, Germany
Wind Tunnel University of Karlsruhe
1 : 86
Atmospheric boundary layer
40'000 EURO

EUROTrough Design Selection



- Torque box design allows weight reduction compared with existing collector design
- Torque box design has the lowest deformations under dead and wind loads
- Torque box design will allow additional collector elements per drive
- Higher structural stiffness will improve collector performance
- Necessary assembly jigs will be more simple and less costly compared with the LS-3 collector

→ Torque box selected



Final Wind Load Assumptions for EuroTrough

Operation Wind W_{op} :

Definition: Wind speed: **0 m/s – 14,3 m/s** Position: any

Criteria No design criteria

Economic Design Wind $W_{90\%}$:

Definition: Wind speed: **7 m/s** Position: any

Criteria: Deformations (energetic losses) within tolerances

Transient Wind W_{trans} :

Definition: Wind speed: **21 m/s** Position: any

Criteria: Stress within tolerances + maximum drive power

Survival Wind W_{surv} :

Definition: Windspeed: **31,3 m/s** Position: Stow

Criteria: Stress within tolerances

Loading and Material Safety Coefficients

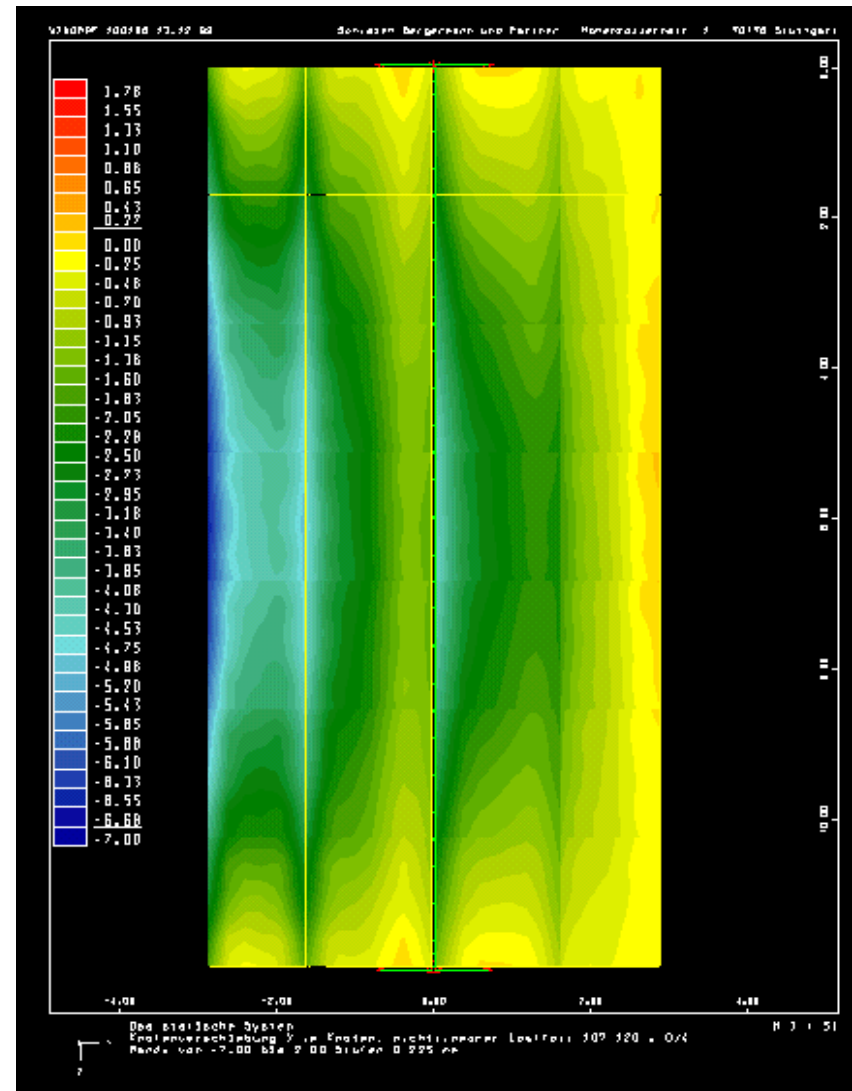
Safety coefficients were reduced compared to EURO-CODE for structural engineering

Deformation Tolerances for 12 Segment Collector

Load	Max. Global Torsion mrad	Avg. Surface Distortion mrad	Maximum Displacement mm
Dead Load	-	2	4
Dead Load + Design Wind Load	5	3	6

Manufacturing and Installation Tolerances

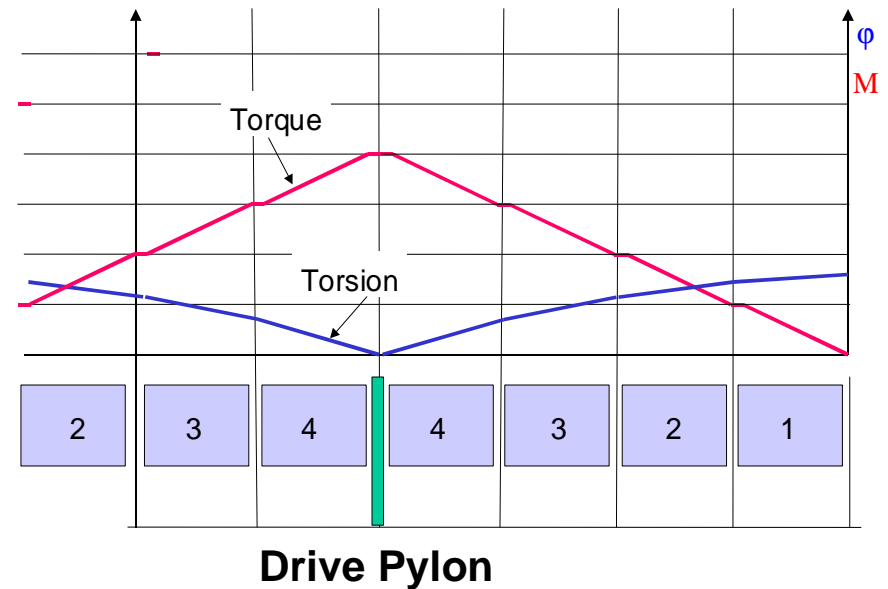
Reflector Error:	average < 3 mrad
Position of Absorber tube x,y	$\pm 10\text{mm}$, $\pm 10\text{mm}$
Lateral deviation of the outer reflector edge	$\pm 5\text{mm}$
Tracking error	< 3 mrad



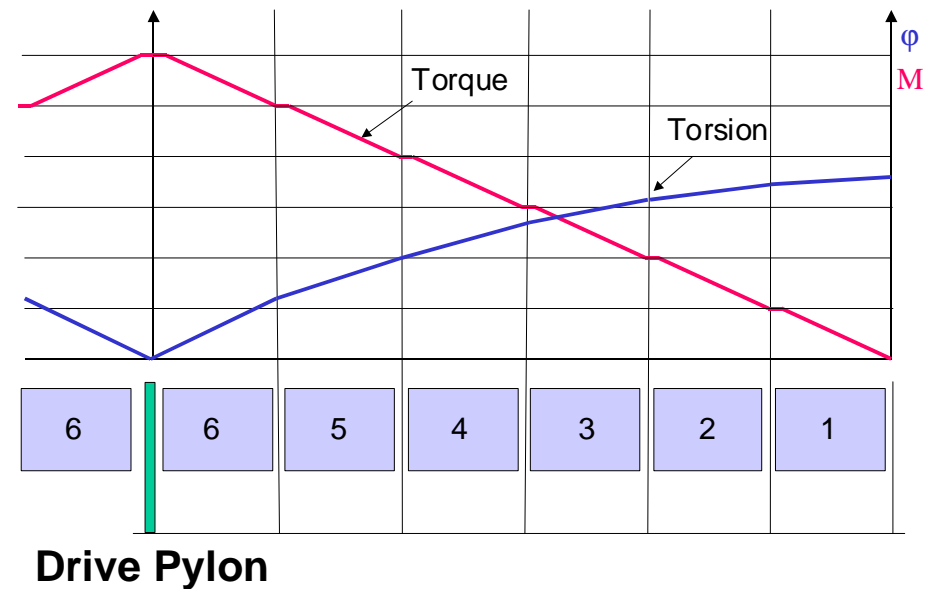
Gravity, 7m/s Wind

Collector Length vs Torque and Torsion

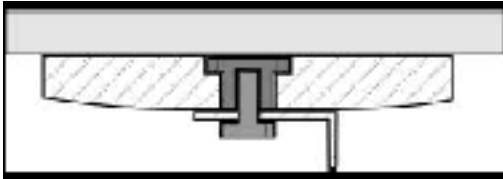
Increase of torque and deformation
due to wind forces for
EUROTROUGH with 8 segments per drive



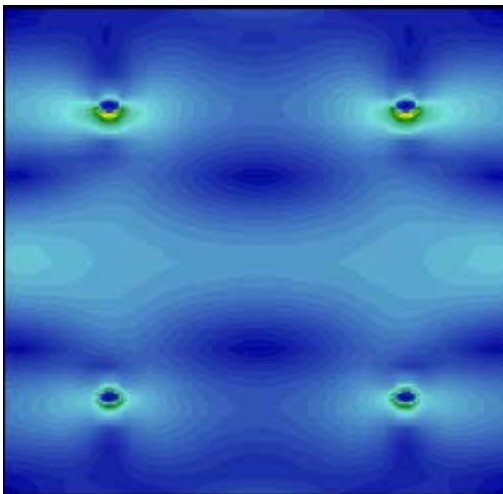
Increase of torque and deformation
due to wind forces for
EUROTrough with 12 segments per drive



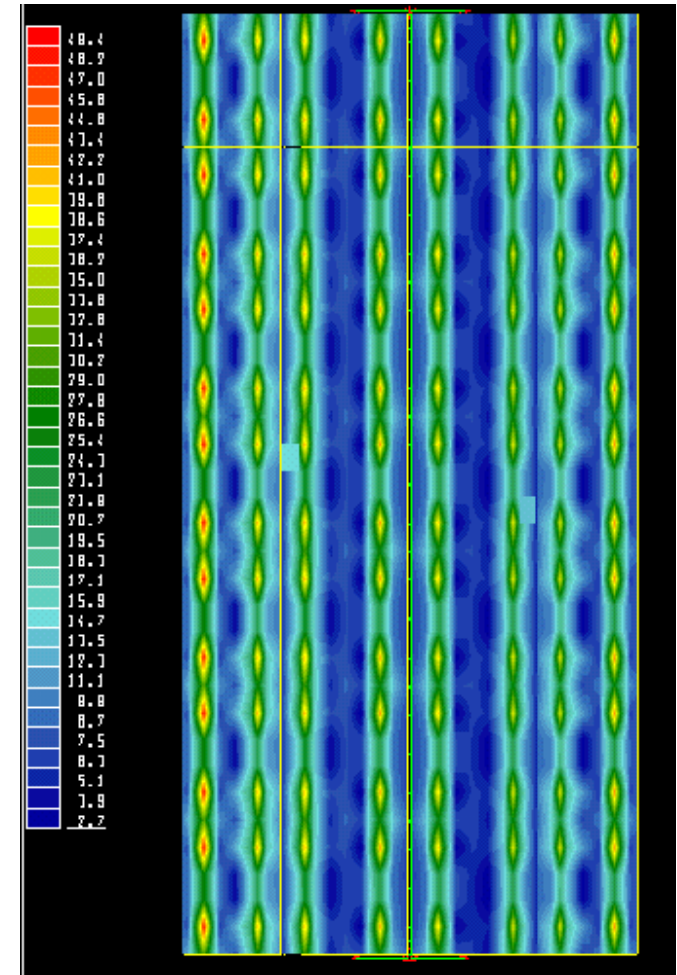
Mirror Stress Reduction by 50% vs LS2/LS3



Optimization of
Mirror Fixation

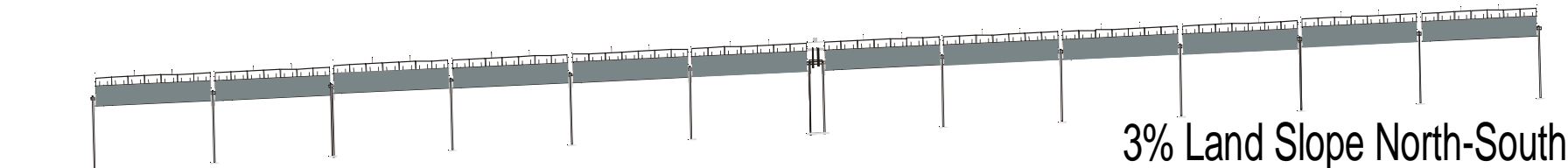


Mirror stress level under survival conditions
Position: Stow; Wind: 31,5 m/s

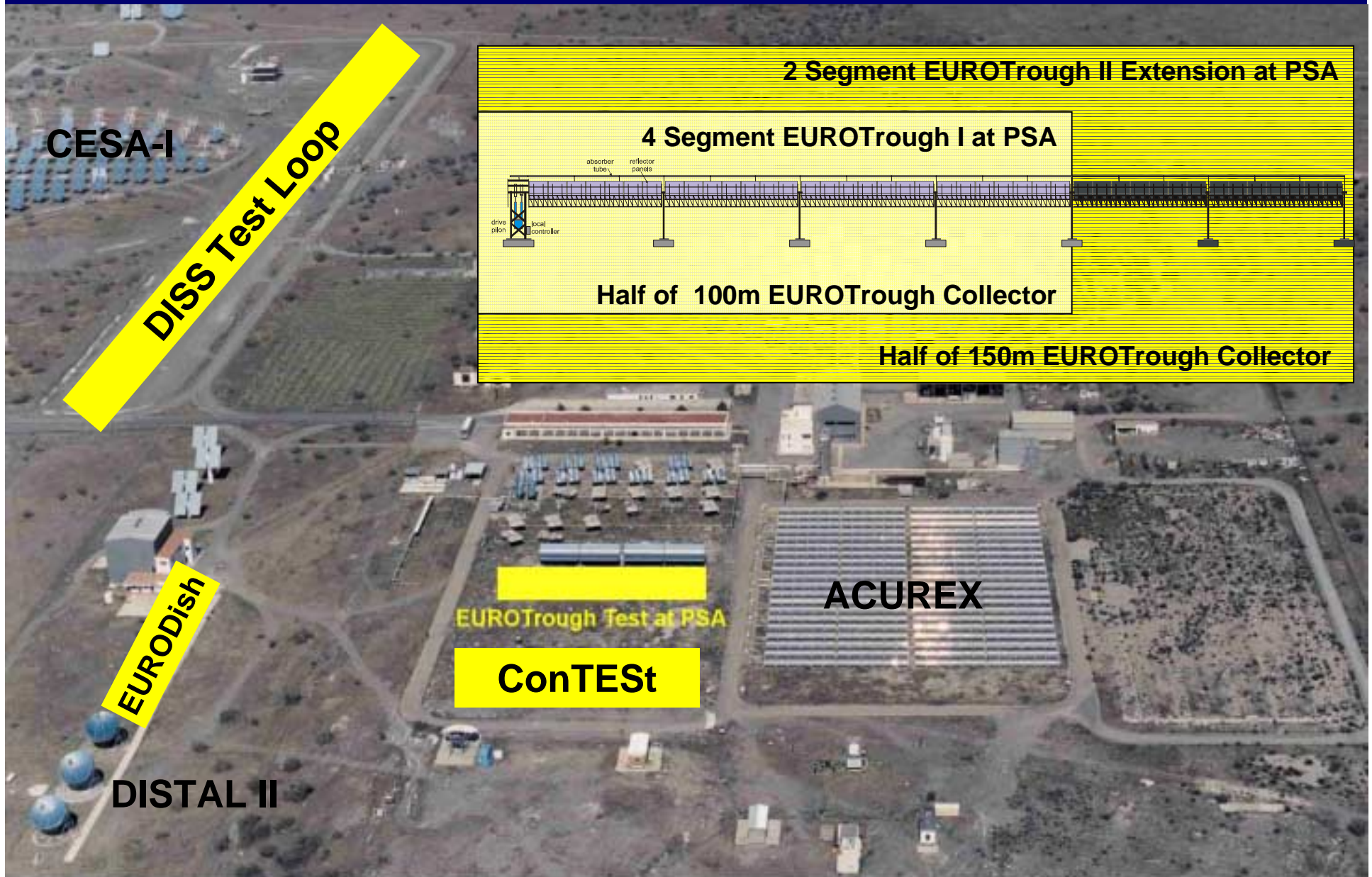


150 Meter

3% Land Slope North-South

- 
- A technical diagram showing a long, low-profile solar trough collector system. It consists of a series of vertical supports holding up a long, slightly curved collector tube. The system is shown installed on a ground surface with a 3% slope. The text '150 Meter' is positioned above the collector, and '3% Land Slope North-South' is positioned below the right side of the collector.
- Torque box with less bending/torsion and reduced weight
 - Increase of Collector length up to 150m/12segments
 - 50% reduced mirror stress by new pad fixations
 - Installation on 3% ground slope with new bearings
 - Suitable for HTF and DSG
 - Structural part items minimized to reduce transport cost
 - Rig cost and assembly cost reduced
 - New tracking control

EUROTrough Prototype Test at PSA



VENTING VALVE

ET I

ET I

ET I

ET I

ET II

ET II

TE E1

TE E2

TE E3

TE E4

TE E5

TE E6

TE E7

TE 01

PD1 E2

LS-3

LS-3

LS-3

LS-3

VENTING VALVE

TE 03

TE 02

TE 04

TE 01

TE 06

TE 07

TE 08

TE 09

TE 10

TE 11

TE 12

TE 13

TE 14

TE 15

TE 16

TE 17

PT E1

LI 01

LI 02

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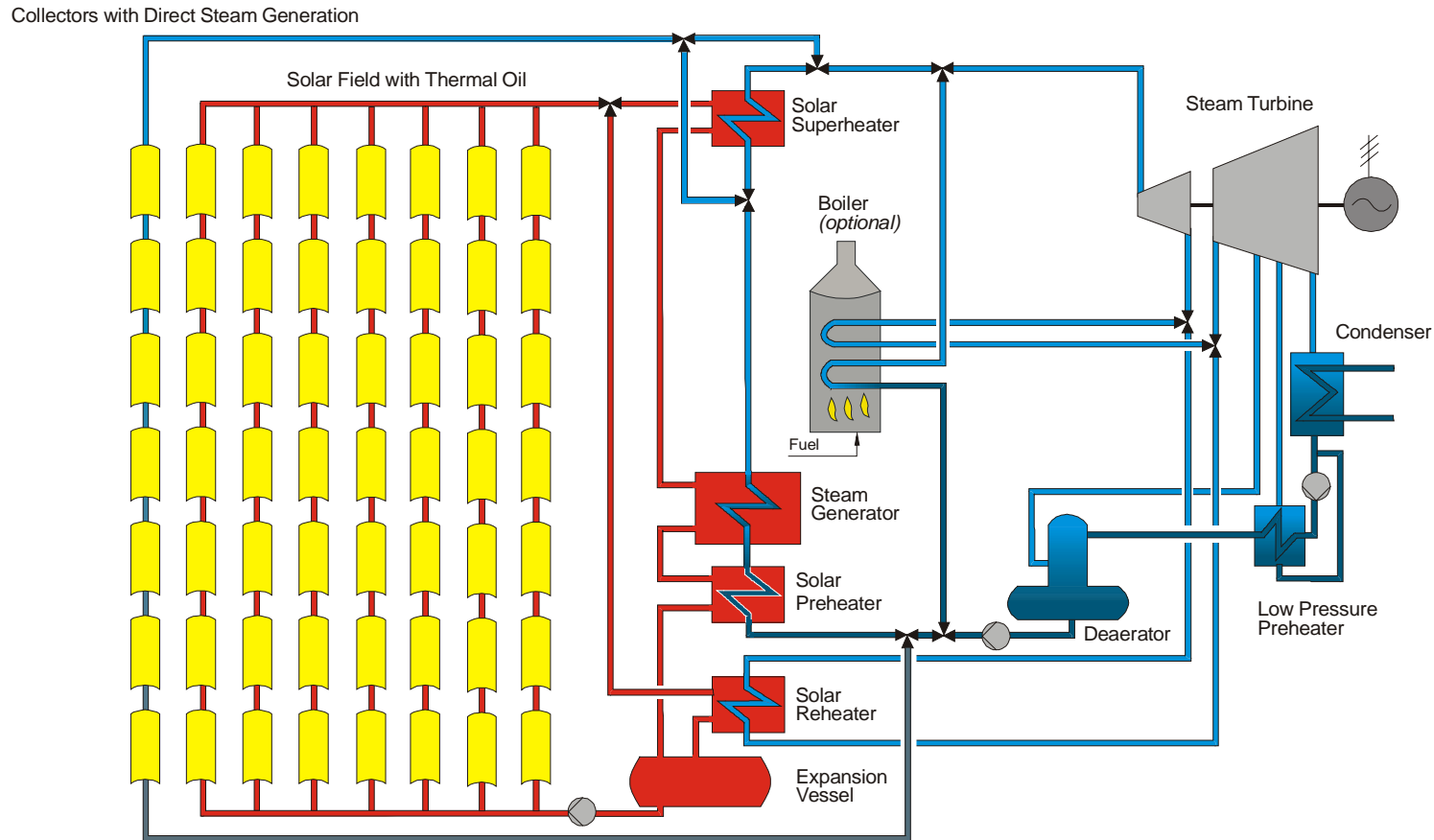
LS-3 & EURO Trough II
HTF TEST LOOP
P&I DIAGRAM

The background of the slide is a close-up photograph of numerous Chinese coins. The coins are primarily blue and silver, with some showing the number "5" and the character "角" (jiao). They are scattered across the frame, creating a textured, metallic background.

Consortium Agreement Marketing Strategy International Cooperation

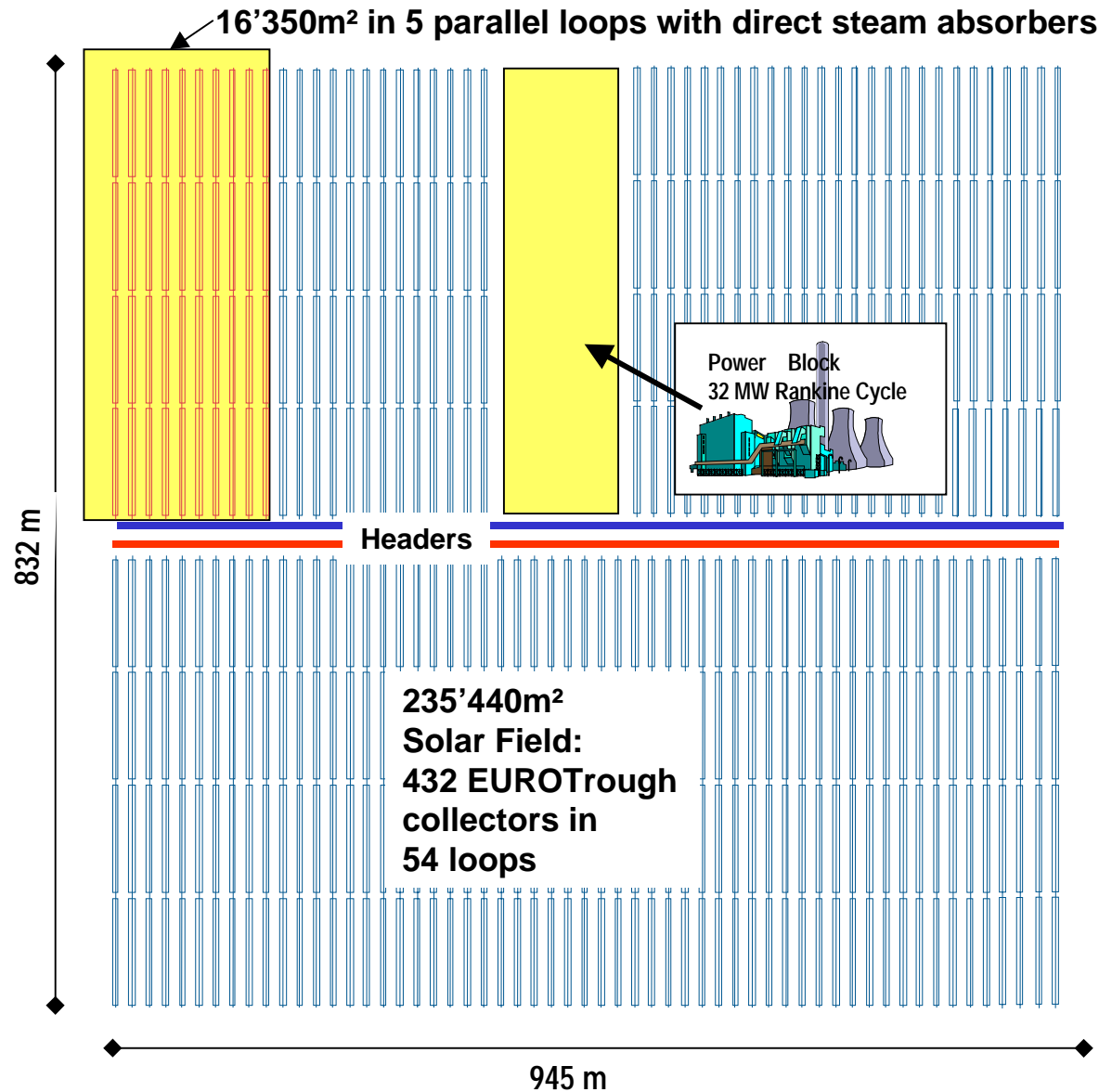


AndaSol32: 1st Project with EUROTrough & DSG



AndaSol32 Partners: Gamesa, Iberdrola, Agrosol, Pilkington/Flabeg, Solar Millennium AG, DLR, Ciemat

AndaSol32: 235'000m² EUROTrough & 16'000m² DSG



Solar Thermal (like all Renewables)

- is not competitive with least cost conventional alternatives
- needs financial subsidies (grants, kWh premiums, tax credits, soft loans, credit warranties, ...)
- needs political support from national, multinational (I.e EU) or multilateral organisations to achieve market introduction

National Governments

- don't like subsidize with their national taxes foreign suppliers (1cent/kWh premium fo a 50MW solar plant is 1 Mio USD subsidy per year)
- want to earn merits and votes with creation of jobs, local hi'tec, etc.
- don't support any "not invented here"

Multinational Donors (like EU) want

- involvement of their members

Multilateral Institutions (like World Bank, GEF)

- fair competition

In this phase, solar thermal industrial developers must avoid

- create a broad jealousy of the non-profit companies in the renewable scene, who will intervene against subsidy and support at the national level

Based on these lessons learnt in Spain and in Brussels, the EUROTrough partners have committed themselves in their consortium agreement to

- open the EUROTrough platform (as the PC platform)
- intend to distribute the design widely
- by giving every partner the right to license the design to any client (even the competitors of other partners)

in order to give a broad community the chance to make money with solar thermal thru EUROTrough

Example: ANDASOL proposal



How Can the Partners Nevertheless Make Money?

The EUROTrough Consortium follows the principle:

- Give Away Kerosene Lamps and Sell Kerosene
- Give Away Cell-Phones for 1\$ and Profit from the Calls
- Open the Trough Platform like in the PC Business to competition and gain a market
- Make EUROTrough national anywhere
- Make EUROTrough “invented there”
- Involve from the beginning other national and international players to gain their lobbying support

The EUROTrough Consortium

- **does not want to make the money with the EUROTrough design itself, but wants**
- **to sell equipment (mirrors, structures, absorbers, trackers)**
- **and to sell services (project development, engineering, management, operation, construction, ...)**

Like in the PC business, where nobody wants to invent himself a costly operating system or hardware bus, power project developers don't want to spend their money in reinventing and requalifying the parabolic trough. They want to spend minimum money in that and would rather use standard solutions. (Only within the solar thermal community we all have the desire to invent our own collector and solar concept...)

In view of the limited resources for solar thermal, the EUROTrough Consortium advocates to

- **join forces between Europe and US**
- **avoid duplication of efforts**

The EUROTrough Consortium offers to

- **fully share the EUROTrough Design with interested US partners**
- **bring it into a joint NEXTrough US-European effort**

The EUROTrough Consortium proposes

- **prequalify the EUROTrough in a prototype test at PSA**
- **demonstrate a loop of 8 Collectors at Kramer Junction**
- **jointly develop commercial scale projects**



Solar Thermal Market Problems